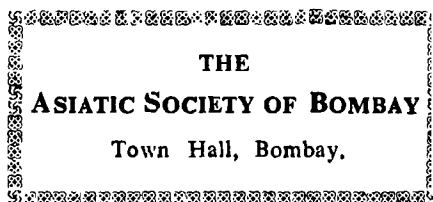


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NOTES
ON THE
ECONOMIC MINERALOGY
OF THE
HILL DISTRICTS
OF THE
N.-W. PROVINCES OF INDIA.

By E. T. ATKINSON, B.A., F.R.G.S.,
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NOTES

ON THE

ECONOMIC MINERALOGY

OF THE

HILL DISTRICTS OF THE N.-W. P. OF INDIA.

ECONOMIC MINERALOGY.¹

THE mineralogical resources of the Kumaun division early obtained the attention which their traditional value assumed to be due to them, and it was one of the directions to the first Commissioner to procure specimens of the ores to be found in Kumaun and transmit them to the mint for assay. Specimens of copper ore from the mines in Sira and Gangoli were accordingly forwarded to Calcutta in 1815, but the report was not favourable; for, if the specimens sent were fair samples of the ores in general, it was doubted whether the mines could be worked to advantage, one specimen yielding but 24 per cent. of metal, and the other but 25 per cent. of metal.² The Government were, however, not satisfied with this report, and in 1817 deputed Mr. A. Laidlaw as mineralogical surveyor to accompany Lieutenant Webb's Mining history.

¹ I have prepared this short notice of the mineralogy of Kumaun, at the request of the Director of Agriculture and Commerce, from my notes for the chapter on Hymálayan mineralogy of the Kumaun Memoir.—E. T. A.

² To Government, dated 26th June, 1815: from Government, dated 13th January, 1816. For further information on the mineral resources of Kumaun see Moorcroft's Travels, I., 7: As. Res., XVIII., 236: Rec. Geol. Sur., 1871, 19: J. A. S. Ben., VI., 653; Glean. in Sc. I., 230.

Graphite, Glean. in Sc. III., 280; J. A. S. Ben., XXIV., 203; N.-W. P. Rec., III., N. S., 371: G. India Rec., XVII., 58.

Iron ores and works, N.-W. P. Rec., XVIII., 1: Rec. G. India, Sup., VIII., 37: XVII., 1: XXVI.: Bhábar iron works, Agra, 1856.

Copper ores and works, J. A. S. Ben., VII., 934; VIII., 471; XII., 453, 769: XIV., 471: As. Res., XVIII., 239: N.-W. P. Rec., III., N. S., 22: Glean. in Sc. I., 228.

Salajit, J. A. S. Ben., II., 321, 482: Rec. Geol. Sur., II., 86; III., 43.

Lead, Glean., in Sc., I., 230.

Lignite, As. Res., XVI., 387, 397.

Gypsum, As. Res., XVIII., (I), 216,

party through Kumaun. His orders¹ were to consider the examination of the mineral resources of the country his primary duty, though at the same time he should not feel himself debarred from bestowing attention on any other matters deserving of scientific research, so far as such investigation did not interfere with his more immediate duties. These instructions further go on to say:—"You should ascertain the existence or otherwise of mineral productions applicable to purposes of public use, or available as a source of revenue; and report on the practicability of bringing them to account. The existence of iron and copper ores in considerable quantity has already been ascertained; but as the working of these metals might injuriously affect important articles of British import, it is not designed that your attention should be occupied in detailing any practical arrangements for that purpose; you will not, however, consider yourself debarred from prosecuting enquiries into any circumstances regarding them which may be of sufficient interest to science to merit particular notice. In every part, indeed, of your researches it is the wish of Government that, in the first instance at least, you should contemplate rather the general capabilities of the country which you are to visit, than the special means necessary for bringing them into action in any particular district; though, of course, the facility or difficulty with which metallic ores or other useful minerals could be raised and brought to market must be a leading point in your observations on them. The minuter details of machinery, mode of working, &c., are what it is meant to postpone, as these will be the subject of future determination, when the whole result of your survey shall be before Government."

In 1826 Captain J. D. Herbert submitted his report on the mineralogical survey of the province.² This was followed by a report in 1838 by Captain H. Drummond, of the 3rd Light Cavalry, on the copper mines at Rāi in Gangoli and at Sira in Bārabāsi.³ Captain Drummond had brought with him from England an experienced Cornish miner, Mr. Wilkin, to examine

¹ From Government, dated 11th July, 1817. Mr. Laidlaw died at Pithoragarh in 1836, and I have not been able to procure any of his original reports

² To Commissioner, dated 10th January, 1826.

³ J. A. S. Ben, VII., 934; and Stat. Kum., p. 358.

the mines already worked, and proposed that, with a view of ascertaining their actual value, a certain sum should be advanced by " Government for an experimental opening of such mines as might appear best suited to the object in view. This proposal was accepted¹ by Government, and a sum of Rs. 2,415 (subsequently increased by Rs. 1,000) was allotted to carry out the designs furnished by Captain Drummond. A report² on the experiments then undertaken was rendered by Mr. G. T. Lushington, Commissioner of Kumaun, in 1842.

The place selected for the important purpose of determining the advantages or otherwise of working the mines under European superintendence was the Pokhri copper mine in pargana Nāgpur in Garhwāl. The works were carried on from 1838 to 1841 with a net loss to Government of Rs. 7,384. The Commissioner considered this complete failure to be due to the poorness and scarcity of the ores found, and not in the least to any want of skill or industry on the part of Mr. Wilkin, or any injudicious selection of the places for experiment. Mr. Reckendorf, a mining engineer, visited these mines again in 1845, and in commenting on the deductions to be drawn from Mr. Wilkin's experiment gave it as his opinion that the operations then undertaken should not be considered as conclusive against the value of the mines.³ The experiment should have been confined to driving a shaft some thirty or forty fathoms below the old mines, and not to collecting ores which might have been a good addition in smelting other ores, but the smelting of which alone could never be profitable. Nothing of importance, however, resulted from this the first attempt to obtain some accurate information regarding the mineral resources of the Himālayas. Again there were no proper appliances for smelting, the loss from which by the native method adopted was very great, and the ores used, from their nearness to the surface, had already lost much of their value by the slow metamorphosis of pyrites into sulphate of copper. On the whole, Mr. Reckendorf's opinion was favourable to more extended and expensive operations in the hands of a private company. Captain Drummond also combated⁴ the conclusions arrived at by Mr. Lushington as to the mines not

¹ To Commissioner, dated 26th November, 1838.

² J. A. S. Ben., XII., 454; and Stat. Kum., p. 367.

³ J. A. S. Ben., XIV., 471; and Stat. Kum., p. 385.

⁴ In a pamphlet published in London in 1845, and Stat. Kum., p. 393.

affording a fair field for investment of capital, and in this was supported by the testimony of Captain Glasford, Executive Engineer ; Captain J. D. Herbert, Superintendent of the Mineralogical Survey ; and the experts Wilkin and Reckendorf, who had actually visited and partially worked the mines. The sums hitherto expended were barely sufficient to pay for the expenses of discovering and laying open the lode, and were utterly insufficient to carry on the experiment in the only way in which it could be made to pay. Nothing was undertaken until 1852, when the mines were again opened on the same footing, but the result was failure as complete as before. No attempt has since been made towards placing the copper mines of Garhwál under European superintendence. In 1872, however, a European leased the mines and continued the extraction of the ore according to the native method, but was obliged to abandon the process, as he found the cost of the metal when manufactured more nearly approached the current rate for silver than that obtainable in the market for the best foreign copper. The copper mines in Kumaun have never been worked under European superintendence, and any remarks that I have to make on their value or fiscal history will be found under the notice of the mines themselves.

Connected with the history of mining enterprise in Kumaun special prominence must be given to the Kumaun Iron Works

Kumaun Iron Works Company still in existence, and whose Company.

origin is no doubt due to the continued belief, in spite of successive failures, in the possibility of turning the utilisation of the mineral resources of the province into a profitable investment. These had again in the regular cycle of inquiries become the subject of much speculation. From a review of the information before Government and the results of certain experiments made in 1856, the Directors of the East India Company sent out a Mr. Sowerby and a large staff of mining assistants in 1857 to carry on the smelting of iron on account of Government in the interior. At the same time a number of private individuals under the style of Davies & Co. were permitted to undertake operations for the same purpose in other parts of the lower hills.

The avowed object of the Government enterprise was to induce private companies to work by demonstrating the financial

and physical possibility of carrying on iron works as a remunerative industry in this province. Messrs. Davies proposed to take over the tract between the Dhabka and the Bhakra, and their proposals were accepted, with an assurance that they might proceed in confidence to make their arrangements, as Government would grant the lease sought. They therefore took over the Khúrpa Tál works in the rains of 1858, and paid their cost price in 1863. This company also erected buildings at Káládhúngi at a cost of Rs. 1,25,000. On the failure of the Government works at Dehchauri, said by Dr. Oldham to have been caused by the extravagance and incompetence of the superintendent, Colonel Drummond offered to take over the works at a valuation. These works were given over to Drummond & Co., who paid the capital under agreement into the treasury in 1861. The forest rules were relaxed in favour of both companies, so as to allow them entire control over the fuel supplies, and eventually in November, 1862, both companies were amalgamated under the title of the North of India Kumaun Iron Works Company (Limited).

A license was granted by Government, but, unfortunately for the company, not executed till it was too late, and the deed of agreement contained briefly the following clauses:—

- 1.—That a capital of 3½ lakhs of rupees should be paid before execution of the deed.
- 2.—That the company should pay Rs. 83,585 as value of works at Dehchauri, Ramgarh, and Khúrpa Tál made over to them by Government in four instalments, on or before the 1st September, 1862, 1863, 1864, and 1865 respectively; and in default of one payment the whole to become immediately due.
- 3.—To pay yearly, for the first three years from 6th June, 1861, a rent of Rs. 1,500, and thereafter a yearly rent of Rs. 2,500 and a royalty of one rupee per ton of cast or wrought iron produced, and eight annas per ton of iron ore raised and sold without being smelted; the said royalties not to be paid unless they exceed, and only so far as they exceed, the rents of Rs. 1,500 and Rs. 2,500 before named; payments to be made on the 1st May yearly.
- 4.—To erect during the third, fourth, and fifth years suitable furnaces with requisite appliances for the smelting or blasting of iron (no number mentioned), and during these third, fourth, and fifth years manufacture at least 750 tons of iron per annum on an average, and thereafter till the end of the term of 50 years

manufacture 2,500 tons of iron per annum on an average of three years, to be struck in May each year. 5.—That the area of forests at the close of every ten years shall be covered with at least nine-tenths of such timber, like trees as stood upon it at the commencement of the term, and when less than nine-tenths the company to plant to the necessary extent, failing which they shall pay for each default Rs. 20,000. 6.—Not to transfer their lease without the consent of Government. 7.—To keep all roads (not being public ways made by Government) used by them in repair, also their works. 8.—At the close of their term remove their buildings, &c., first giving Government the option of purchasing them at a fair valuation. 9.—On the failure to pay or manufacture as stipulated, Government to enter upon and possess the works. 10.—But if such failure is not due to the neglect of the company they shall be free from such penalty.

The purchase money of the Khúrpa Tál works was alone paid up, but the forfeiture clause was suspended by the local Government in 1868. The forest tract was never given over to the company in the meaning of the agreement, but its revenue has been collected by Government to about one lakh of rupees from 1861 to 1872. The license was not sent up from Calcutta till June, 1864, by which time the company had begun to see that the speculation would not turn out a profitable one. In fact the license deed was not prepared for signature until after the company had suspended operations, and then it was ruled by the solicitor to Government that it ought not to be signed. The map of the tract to be given over to the company was not completed till 1869. So much for the relations of the company to Government, and the delay in dealing with its affairs which has been shown throughout. In June, 1861, permission was obtained for the company's manager drawing against their capital; this was expended with little result, and in 1864, as abovementioned, the company was wound up. This finale was in a great measure, no doubt, due to the company being unable to raise capital in the market, owing to the defect, or rather the want of title, which appears to be ascribable to no fault of their own. Since 1865 correspondence has been carried on in reference to the affairs of the company and plans have been proposed for its resuscitation. In 1872 the works were visited by

Mr. Jones of the Roorkee Workshops and valued ; he makes them worth at present Rs. 1,26,733, with a debt to Government of about Rs. 80,000. There can be no doubt but that the works can be hardly said to have had a fair trial, and the valuable opinion of the Commissioner of Kumaun may be quoted to the effect that there is every reason to believe that, if carefully supervised and fed with capital, the works should at least turn out as favourable under any circumstances as the East Indian Railway. There is no doubt that, in the distance, the fuel difficulty exists, but at Dehchauri and Káládhungi for many years this can scarcely be felt, and under penalties to replant, the company may fairly be allowed to have an unlimited supply from the neighbouring forest. At Ramgarh it is doubtful whether iron manufacture will pay, as the ore, though of the finest quality, lies at a considerable distance from any forests of any considerable magnitude. But it has never yet been settled whether coal does or does not exist in Kumaun, and until this question has received the attention due to it, the eventual absolute success of the Kumaun mines must remain problematical.¹ The increase of railways in Northern India and the development of the resources of this province must sooner or later press these difficulties into notice, and they will then obtain a final solution. "Too much has been written and too little done" hitherto in this direction.

In reviewing the causes of the poor returns from the different mines, one that presses itself into notice on the most cursory inquiry is the comparative inaccessibility of the principal mines. Those of Síra and Gangoli, equally with Pokhri and Dhanpur, are situated on high cliffs in the interior. The talcose and calcareous formations in which the ores are found occupy the high precipitous mountains which build up the outlying spurs of the principal range, and some lie within it. This chain itself is metalliferous, as the lead mines at Ghirti between Milam and Níti, the copper indications at Tola and elsewhere in the Juhár pass, and the copper and iron mines at Polar near Rudrnáth combine to show. The absence of coal and the increasing cost of wood fuel, with the

¹ For the materials for this sketch I am indebted to the office of the Commissioner of Kumaun and a note drawn up by Colonel Ramsay, than whom the company and Kumaun has no more warm well-wisher.

distance it has to be carried when the forests near the mines have been exhausted, materially enhances the cost of production, while the difficulties of carriage in the tracts where the mines lie are often such as to almost preclude the transport of ore for smelting, and the forests in the neighbourhood of most mines only suffice for the most moderate requirements. Another difficulty is the want of labourers. The present workmen only come to work in the mines from the latter end of October to the beginning of April, and many of the less productive mines have been abandoned owing to the miner class turning to agriculture and to supplying the labour market at Ránikhet and Naini Tál. This want, however, could be supplied from Nepal were regular wages and constant employment once established.

Sea-borne copper, though inferior to native copper, is from its cheapness preferred, and until capital is invested in opening up the larger mines and conducting the whole operations on a sufficiently large scale to warrant the permanent investment of capital in machinery and proper furnaces, and other appliances for the more economical working of the ore, mining enterprise must remain as it is—a practical failure in this province. It may be said that these extended experiments have already been tried in the case of the Kumaun iron works, but this remark will scarcely apply, as that is another of those unsatisfactory operations which stopped just at the point where further progress would have decided the question for or against the possibility of making mining speculation a remunerative one in Kumaun. I shall now briefly describe the mode of working and the financial results of the settlements of the revenue from mines from the official reports and papers before describing each mine.

The mode of working the mines is the same for all minerals, and the suggestions for its improvement will
Mode of mining. serve for all classes of minerals. A gallery or passage is cut in the face of the hill with such slight declivity outwards as is sufficient to carry off the water. These adits are more of the nature of burrows than the shafts known in European mining. The section is always small, and in those parts where the hardness of the rock occasions any difficulty in working, the passage is scarcely sufficient to admit of a person in a creeping

posture. In no place will it allow of an erect position. Where necessary, frames of timber formed of unsawn branches of trees, widely and even carelessly constructed, are set up to support the roof and sides. Accidents are therefore not uncommon, and the frequent falling in of the mines is one result of these imperfect protections.¹

The ore as well as the rock is excavated by a very indifferent kind of pickaxe, the handle being made of
Made of excavation. a piece of wood with a knob at one end, into which a piece of hard iron is thrust and sharpened at the point. This, with a miserable iron hammer, wedge, and crowbar, constitutes all the apparatus that the native miner has to depend upon. It is plain that with such tools no hard rocks can be penetrated, nor can the softer ones be worked with much facility, and to this fact may be attributed the universal smallness of the passages throughout the mines, as the native miner can have his passage no larger than the rock which encloses the ore and its matrix will admit of. Proper pickaxes and steel gads (wedges) should therefore be substituted instead of the inefficient tools in use, and when blasting may be required the necessary materials should be provided. The miners work during the day, using torches made of dry pine.

The ore is removed from the mine by boys, who pick up the stuff with their hands and put it into skins,
Removing the ore. which they drag along the floor to the entrance of the mine. In most mines the greater part of this work must be done in a creeping posture, the string from the skin being fastened around the waist of the dragger. In place of this method wheelbarrows or sledges on four wheels and shovels should be used when the passages are enlarged and properly supported with sawn timber.

The ore or *dhūn* being delivered at the mouth of the mine is reduced to a small size either by the water-mill or by the manual labour of women. A
Crushing the ore. large stone is placed on the ground on which they lay the ores; they then, either with a stone or a large hammer, and more frequently the former, proceed to pulverize the ore and pick out the impurities.

¹ Paras. 19, 20, Captain Herbert's report already quoted.

in this way a woman may manage one to two maunds (82lbs. avd.) a day, according to the hardness of the ores. In Cornwall a woman will pulverize from 10 to 15 hundredweight per day, according, as in the former case, to the nature of the ores. The method in practice there is, first, to dispense with the picking; secondly, to have the ores elevated, so as to enable the individual to stand while working, and to have a plate of iron about a foot square and two inches thick on which the ores are broken with a broad flat hammer. The impurities are then finally separated by a peculiar mode of dressing the ores with a sieve, by which a boy gets through with from one and a half to two tons per day. The ores are conveyed to the women, and from them to the boys by a man who attends for that purpose.

The washing of the ore in Kumaun also is performed by women, who carry the stuff from the entrance of the
 Cleaning the ore. mine to a stream in baskets, where they contrive by dabbling it with their hands to wash off the mud and finer particles of the earth. They then proceed to pick out all the pieces of ore they can get hold of; or, in the case of what may be submitted to the water in a comminuted state, they work this against the stream, so as to gather it clean at the head of a small pit by handfuls; but, from the bad construction of the pits, it is with difficulty that this is performed. After picking up any larger pieces of ore which may have gone back with the stream, they scoop out the refuse with their hands, and then proceed with another charge. In Cornwall one woman provided with a wheelbarrow and shovel for the conveying and washing of the ores, and a boy with a sieve for dressing them, as formerly mentioned, would accomplish an equal task to that of ten women on the system described.

The drainage of the mine is managed in a proper manner by
 Drainage. an adit. -But whenever any attempt is made to go below it, as is the case in most, if not all, the mines, the water is then raised in wooden buckets handed from one man to another, until they reach the adit into which they are emptied. In this manner six, ten, or even more men may be employed, whilst only an inferior number can be spared for excavating the ores. At the Sira mine, for instance, six men are constantly engaged in lifting up the

water, and there are only two at the ores : the work done by these six men could be effected with a hand-pump by one man ; but in order to keep the pump constantly going, two men might be required, and the remaining four added to the number of those who are excavating.

The furnace of the smelter is very simple, and is made of common stone and clay faced with slabs of quartzose schist, luted with a compost of chaff and clay. It is about 3½' long by 2½' broad, with an ashpit about six inches square, all of which are built inside a house about 12' by 14', of which the roof is composed of planks. The operation of smelting takes about 28½ hours, during which time the fire is kept up, and after that the facing slabs and luting require renewal. The implements used are a crowbar, poker, shovel, and a pair of buffalo hides, dressed whole, to form the bellows, the neck of which forms the nozzle, and the buttock the valve for the ingress of air. The hides for making them are worth twelve rupees a piece.¹

The furnace being freshly luted, the ashpit is filled with charcoal dust and chaff, and a fire being lit, six baskets of iron ore, each containing about thirty sers (the ser = 2 lbs. 2 oz. avd.), are placed round the fire. The blast is then commenced, one bellows being inflated while the other is undergoing depletion. In about half an hour the slag commences to flow from the floss-hole, which is kept open by a poker. In about two hours more, the ore having subsided considerably, two more baskets of ore and a corresponding supply of charcoal is given with a new luting for the bellows nozzle. In another two hours, this having also subsided, the charge is deemed ready. The fire is then raked out through the floss-hole, and the charge, consisting of a pasty mass called *phalka* or *jharuj*, is shoved out with a crowbar by the Dhanauriya or smelter. The same operation is repeated until seven blooms are obtained consuming thirty-eight baskets of ore, thirty-one of which are converted into the seven blooms, and the remainder, comprising the partially roasted ore, become the property of the smelter. The charcoal consumed weighs 340 sers, or a little more than the seven blooms, which weigh 327 sers, or about one-third of the ore expended (930 sers). Each bloom

¹ Beckett, III., Sel. Rec., N.-W. P., 25,

consists of three qualities of metal, all intermixed with earthy particles. These are kept separate, and are broken into small pieces before being sent to the Khatauniya or refiner.

The furnace of the refiner is smaller, and the implements required are a pincers, poker, two or three sledge-hammers, an anvil, and bellows.

Refining the ore.

The fire being lit, a mixture of one-sixth of first quality, one-sixth of second quality, and the remaining two-thirds of third quality, in all about six sers of bloom metal, is placed on the hearth opposite the bellows, with the larger pieces nearest the fire. The blast being commenced, in a quarter of an hour the slag begins to flow, and in another quarter of an hour the metal (now a porous, pasty mass) is taken out of the fire and subjected to the blows of two or more sledge-hammers; the blows being slight at first, to prevent the metal flying into pieces, but as it becomes more solid, they are given with the full force of the workmen. Meanwhile a fresh supply of bloom-metal is placed on the hearth, as at first. The hammered mass, after several beatings and hammerings, assumes the shape of a small bar, weighing one and a quarter ser; it is thick in the middle, and tapering to either extremity, and six sers of charcoal have been used in its formation. This bar is now fit for the market, and is called by the workmen *phula*, but by the plains-people *pain*. The charcoal used by the refiner is made from the dry trunks of fir trees which have been felled for two or more years, while that made use of by the smelter is made from small green wood. The refiner class is subdivided into another, called Bhadeliya, who, instead of making the iron into bars, manufacture it at once into cooking utensils. Nine hundred and thirty sers of ore produce 327 sers of bloom-metal, which in its turn produces 82 sers of marketable bar-iron, or only 8·8 per cent. The bloom operation consumes 340 sers of charcoal and the refining process 667 sers, so that for every ser of iron produced 8·2 sers of charcoal are consumed. The Swedish forge only consumes 1·33 times the weight of the iron produced. The mode of manufacturing copper differs in the addition of limestone as a flux, in the proportion of five of the latter to six of the ore. The charge too only amounts to three sers of ore, and the produce to seven tolas of metal. From 100 sers of ore 2·92 sers of copper are extracted, and 68½ sers of charcoal are consumed in manufacturing each ser of copper.

The mines are leased for a term of years to contractors for a certain sum, and the lessee collects for the season from the different classes of workmen at the following rates: from each *son* or gang of miners Rs. 2½; from smelters Rs. 4½; from refiners of the Khatauniya class Rs. 4½; from those of the Bhadeliya class Rs. 6. The miner is originally sole proprietor of the ore, which he takes to the smelter to reduce into blooms, giving him for his trouble one basket of ore (30 sers) and one basket of charcoal (5 sers) for each bloom turned out; also for each set of seven blooms 16 sers of grain, and food for one man for four days; and at the end of the season a suit of clothes. Sometimes, however, owing to the smelter being largely in debt to the miner, he does not receive any charcoal from him. The smelter can only work for certain miners, generally five in number, not being allowed to work for any other miners; or, in other words, each party of five miners employ one family of smelters exclusively. Each party of smelters must consist of at least five persons, but they generally count eight to ten persons. The share of each party of refiners is 51 per cent., or half of the bloom-metal made over to them to refine, no further remuneration being allowed them. Refiners, unlike the smelters, are not bound to work for any particular person, but may work for any one that chooses to patronize them.

In the roasting and smelting of the ore Captain Herbert recommends a system of reverberatory furnaces for these two different processes. An excellent material is at hand in the indurated talc known as potstone, which though soft is infusible. The simple blast furnace in use in Chili would also be an improvement. It is of a circular shape, similar to a lime-kiln, covered with a dome to confine and concentrate the heat. The ore is arranged in it in alternate layers with the fuel, which is wood, and being lighted it continues burning for a considerable time. When required, the heat is urged by a double pair of bellows worked by a crank turned by a water-mill.

The methods of reduction practised in England, where the subject is best understood, vary with the English system. ore, and even with the establishment.

But the differences are trifling and only affect the minor details. The two great objects to be effected are, first, by a proper calcining heat to drive off the volatile ingredients sulphur and arsenic, and to oxidate the iron, thereby promoting the fusibility of the ore, and consequent separation of the metal from the scoria when in fusion; and, secondly, by an intense and properly continued fusing heat to effect the vitrification of all the impurities which thus form a slag at the top and are skimmed off while the metal sinks down in a comparatively pure state. To promote this vitrification of the ingredients occasional additions are made to the ore as the case may seem to require, though in general the run of the ores is such as to require little beyond a few slags of an old smelting. The operations of roasting and smelting are repeated several times, each smelting being followed by a roasting, to expedite which effect the copper is after each smelting, but the last, let into water to be granulated. This separation of the metal into such small parts assists the calcining power of the furnace, and the work is more speedily effected than if performed on the mass. After the last smelting comes the process of refining or poling, which consists in keeping the copper in a melted state covered with charcoal, and introducing from time to time a wooden pole into the melted mass to produce the evolution of gaseous matters. Lead is sometimes used both in Hungary and England to expedite the previous operations of the refinery. The oxides of this metal are amongst the most powerful vitrifiers known. As such they are effectual in the assay and refinery of the precious metals, and as such they may be also used with copper. But the process requires attention, for if not stopped in time, or too much lead added, the copper itself will be oxidated and vitrified.

The process of manufacturing iron from the ores is different from that of copper, inasmuch as none but the oxides or carbonated oxides of the former metal are ever employed. In the copper ores, that is, in those which occur in any quantity, the metal is combined with sulphur, which can only be driven off by repeated roastings. In the iron ores the metal is united to oxygen and mixed with various earthy impurities. In reducing these ores, then, there are three distinct points to be attended to: first, the provision of a substance which shall effectually take the oxygen from the ore, leaving the metal mixed only with

its earthy constituents ; second, the proportioning the flux used to those earthy ingredients so as to insure a complete vitrification of them and separation from the metallic particles ; and third, a sufficient heat to fuse the latter, that the separation and reduction may be more complete. The first point is attained by using a sufficient quantity of charcoal in the reduction of the ores ; the second by adding, as the ore may require it, limestone or other flux ; and the third point is only to be effected by using a powerful blast furnace.

It is not easy to give the outturn from the mines, the arrangements are so intricate and the returns so imperfect. In 1868 about 29 maunds of copper were raised from the Kumaun mines, and in 1869 the same mines yielded the same amount, of which 21 maunds were exported. The Dhanpur mines in Garhwál yielded 10 maunds of copper in 1869, but every year since the produce has decreased. In 1868 the Kumaun iron mines yielded about 2,000 maunds of metal, and the Garhwál mines about 1,752 maunds, while the returns of 1869 give 5,153 maunds for Kumaun and 529 maunds for Garhwál. Besides this an immense quantity of copper is imported into Kumaun in the shape of manufactured vessels for culinary purposes: about 2,000 maunds of iron also are imported from the plains against 155 maunds exported. No reliance can be placed upon the estimates of outturn in recent years, as the mines have been leased for a term of years, and the lessees are not inclined to have their affairs too closely examined.

Previous to the Gurkha conquest of Garhwál the copper mines of Nágpur are said to have yielded Rs. 5,000 Gk. a year, or about Rs. 3,800 of our money. The entire mineral revenue of Kumaun and Garhwál, including mint dues¹ on the coinage of copper pice, had fallen in 1812 to Rs. 4,800 Gk., equivalent to Rs. 3,600 British currency. During the earlier years of British rule the mines in Garhwál, with the villages usually assessed with them, were leased for Rs. 1,850 a year, and those in Kumaun for Rs. 850 a year. Up to the year 1826 the revenue of the

¹ These mint dues were collected for a few years under British rule at the mines of Dhanpur and Gangoli, and at one-half per cent. yielded a revenue of Rs. 300 a year. To Board, dated 6th August, 1821.

Kumaun mines was included in the assessment of pargana Rāngarh, and that of the Garhwāl mines in pargana Dhanpur and subsequently was accounted for in the returns of the pargana within which they are actually situated. Between the years 1815 and 1840 the revenue derived from mines averaged as follows:—

	Kumaun.	Garhwāl.	Total.
	Rs.	Rs.	Rs.
Copper ...	801	2,086	2,887
Iron ...	1,905	226	2,131
	<u>2,706</u>	<u>2,312</u>	<u>5,018</u>

The highest mineral revenue of the province for any one year amounted to Rs. 5,417. This return was not altogether due to the smelting of ore, and included the land revenue of villages attached to the mines for the location and support of labourers. Mr. Beckett in his report ¹ on the settlement of Garhwāl gives the revenue of each mine from 1839-40 to 1863-64. The revenue every fifth year from each class of mine during this period was as follows:—

Class of mine.	1839-40.	1844-45.	1849-50.	1854-55.	1859-60.	1863-64.	Total revenue from 1838-39 to 1863-64.
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
Iron ...	609	727	779	430	272	134	3,764
Copper ...	1,990	2,442	2,138	1,305	81	627	21,304
Lead ...	...	5	3	3	...	10	64
Total ..	1,599	3,174	2,920	1,738	353	771	25,132
Number of mines worked.	24	25	23	17	11	30	76

In 1865 there were 24 iron, 9 copper, and 2 lead mines worked in Garhwāl, and 33 iron, 35 copper, and 3 lead mines had been abandoned.

In his Kumaun settlement report Mr. Beckett gives the revenue of each mine from the year 1844-45 to the year 1872-73. The

¹ Allahabad, 1866.

revenue every fifth year from each class of mine during this period was as follows:—

Class of mine.	1848-49.	1853-54.	1858-59.	1863-64	1868-69.	1872-73.	Total revenue from 1848-49 to 1872-73.
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
Copper ...	100	48	Nil	120	67	30	2,831
Iron ...	2,274	1,751	1,532	870	929	1,420	46,126
Total ...	2,374	1,799	1,532	990	996	1,450	48,957

The following quotation from the Commissioner's report in 1874 gives the opinion of those best acquainted with the subject on the future of the mining industry in Kumaun:—"Iron and copper abound, but at the present value of labour the mines are worth very little. The *sons* or miners have, as a rule, given up their old trade and taken to contracts. The great attraction to miners in former times was the cheapness of grain in the Khetsari valley, where iron was most extensively manufactured. This advantage no longer exists, for the market at Ránikhet has doubled the price of grain, and the miners would be no longer content to exchange their labour for the small profits on iron. Copper mines are in no greater favour. Formerly some villages where the miners reside were included in the mining leases of Kumaun and Garhwál. These villages have been settled with the miners, therefore they are no longer servants of the contractor. Tea gardens and other labour markets offer much better terms than a contractor, who, at the least possible expenditure, tries to make the greatest possible profit. These contractors know nothing about the science of mining, and they have no money to expend in penetrating beyond the worked-out galleries. In fact the mines have collapsed, and without considerable outlay no reasonable profit can be expected. Labour is expensive, and English copper can be bought at a cheaper rate in the Almora bazar than the local miners can produce it with profit. I expect nothing more from native petty contractors than a pittance which they can realize by the resident miners working when convenient to themselves, when they give half of the ore to the contractors and keep the other half. No doubt there is abundance of copper in Gangoli; but any mines, copper or iron, that

are now worked barely produce sufficient for local consumption. Agricultural instruments are made for the people of the surrounding country, and a few copper vessels; but all the mines in the interior are in remote places, and too far removed from a good market to be of much value."

The gold exported from Kumaun is either obtained from the streams within the province, or is brought down by the Bhotiya traders from Tibet.

Gold. Although no mine of this metal has been discovered in the province there are indications of its existence in Garhwál. The sands of the Alaknanda, Pindar, and Sona furnish a small amount of gold-dust. The Ganges also is auriferous as far as Lachhman Jhúla and the Rám-ganga for a short distance below its junction with the Sona. The washing is nowhere a profitable occupation, and scarcely gives an average of four annas a day for each workman. The gold obtained by washing the sands of rivers paid a small duty during the Gurkha rule, and was leased with the forest duties for a short time after the British occupation, but the amount was too trifling to render its continuance expedient, and it was accordingly abolished by Mr. Traill. Undoubtedly a greater return might be had from this source by the use of mercury, as in Australia, for the purpose of separating the gold from the sand; for as this is afterwards recovered by a simple process of distillation, the expense would be very little more than it now is. Captain Herbert found gold in a matrix of granite near the Alaknanda.

The gold imported from Tibet by traders is chiefly taken in exchange for grain or cloth to balance their accounts, as rupees are taken by them at the hill fairs for the same purpose. The principal gold mines in Tibet, *sár-chaka*, are ten days' journey beyond the borax fields further north and north-east in a district otherwise uninhabitable, named *Sár-bachyád*. These are farmed or managed by a *sár-pan* or gold commissioner on a triennial contract direct from Lhasa. The lessee in 1845 was also Garpan Urku-wá at Gartoh, and paid Rs. 17,000 per annum for the lease. He had 170 miners at work, for whose subsistence he used to send supplies from Pruang. It would also appear to be sometimes the custom to sublet 'claims' at a tax of a *sárjao* or *jao*

of gold, about $7\frac{1}{2}$ mashas, or ten rupees.¹ The gold mines are worked by pits and shafts under ground, where the gold is found in its pure native state, and undergoes no other process than washing and sifting, and after that requires little or no refining. In this state, tied up in little bags called *sár-shu* (H. *Phatang*), weighing about 90 grains, it forms the heavy currency of the country. A superstitious belief holds ground that no large nugget should be removed, as it belongs to the genii of the place, but the Lámá of Gnari is said to have one weighing nearly a ser. Gold is sold at the same fairs as the borax, and is imported to the value of about Rs. 10 to 12,000 annually.

The gold in the bags commonly current has usually not more than 7·73 specific gravity. Even the picked yellow grains have only a specific gravity of 11·96, showing
 Thok Jalang mines. that they are alloyed with some other metal. The grosser impurities appear to consist of iron more or less oxidised. One of Montgomery's pandits visited the gold mines of Thok Jalang in Rohtoh in 1867,² and describes it as a great excavation from 10 to 200 paces in width and some 25 feet in depth, access to the bottom being by means of steps and slopes, the earth dug out being thrown on either side. The digging is carried on with a long-handled kind of spade or an iron hoe, the iron for which comes from Ladakh. A very small stream runs through the gold field, and the bottom is consequently a quagmire during the daytime. The diggers dam up the water, leaving a sloping channel, for an escape. A cloth is then spread at the bottom of this channel, and the channel is supplied by one man with the auriferous earth, and another gives water, so that the gold sinks to the bottom and is caught in the cloth at the end. Some nuggets weigh up to two pounds. The diggers come from the Chang province round Shigatze or Digarcha. There are numbers of abandoned gold fields in different directions about Thok Jalang, and probably a whole series of them from Rohtoh to Lhasa. The Sárpan levies a tax of about half a tola (*saishú*), or two-fifths of an ounce, from each digger. There is no wood, and water can only be had from melted ice. A cold wind blows at all seasons, and in consequence the tents of the diggers are pitched in

¹ H. Strachey, J. A. S. Ben., XVII. (2), 5; Cunningham, *ibid*, XIII. ; J. D. Herbert to Commissioner of Kumaun, 10th January, 1876

² Rec., G. I., H. D., 36.

excavations in the ground to protect them from this wind. The dried dung of yaks, ponies, and sheep afford fuel. The Tibetans cook and eat three times a day, their food consisting chiefly of boiled meat, barley cakes, buttermilk, and tea stewed with butter: they also smoke a great deal. They always sleep with their knees close up to the head and resting on the knees and elbows, huddling all the clothing on to their backs. The price of gold at Thok Jalang was about $5\frac{1}{2}$ to 6 rupees per *saislá*, or 30 rupees per ounce.

Silver was brought down to these provinces from Tibet in former times. It was imported into that country from those surrounding it (probably China), and does not seem to be found in Tibet itself in any quantity. It was sent into Tibet in a crude state in lumps called *doja* or *thaku*, of a general value of Rs. 165 each. Importations from that source have ceased for some time, owing possibly to the great and growing influx of silver in the shape of rupees from British territory. Formerly all borax, salt, &c., was bartered for grain, cloth, &c., but now, while a large amount is still disposed of in that way (probably to procure actual necessities), still, whether it proceed from the increase of trade and the portability of coin for hoarding purposes, or from the existence of a greater demand for silver in Tibet, by far the largest amount of borax is disposed of here for British money. The Bhotiyas too state that our coin is largely current in Gartoh and the other large towns, and is preferred by the inhabitants there to the coinage of other countries. They ask for the Cheharádár Rupayá, or face-printed money.¹ The difference in the exchange now made up in Government rupees cannot be less than eighty thousand to one lakh of rupees per annum. This trade in rupees dates from about 1820, when they began to displace the Srinagari and Ladakhi rupees.

The mines of copper in Kumaun and Garhwál have never been of much practical value either as a source of supply for local consumption, or as offering a valuable return to labour and capital. I shall now describe each in succession, commencing with the Gangoli mines in Kumaun.

¹ Lawder in Proc., Geol. Sur.

The Rái mine in pargana Gangoli is the most important in Kumaun. The ore is chiefly pyrites in a matrix of indurated and sometimes slaty talcose and steatitic schists inclosed in dolomite. In some places the one, and in some places the other, forms the roof and sides of the mine. The dolomite has a large crystalline grain and great tenacity, and forms a perfectly durable work when excavated. The schists when massive may be depended on, and can be easily worked, but, as a rule, they occur of such inferior consistence, having much the appearance of re-united débris, that they require support, and often occasion much inconvenience and even danger. The ore occurs in the schists in numerous strings, having every appearance of being leaders, as they are called, to solid ore, and forming a distinct lode. The strike or direction of the strata is nearly W.-N.-W. to E.-S.-E., dipping at an angle of about 45° to the N.-N.-E. The copper ore is accompanied by iron pyrites which are occasionally found in the pentagonal dodecahedron form, but most commonly in such irregular and anomalous forms as can with difficulty be described. There are a few specimens of grey copper, but the working ore is undoubtedly pyrites. On visiting the mine in 1836, Captain Drummond found the lode about two feet wide, containing a good yellow copper ore, but with a large proportion of its matrix talcose, twenty per cent. only being metalliferous. In 1868-69 these mines fell in and became flooded with water. About a couple of hundred yards to the north, and in the same hill, is another similar deposit of copper. This used to be laid open to the surface during the rainy season, and was then allowed to fall in, so soon as the water employed by the miners to carry off the talcose mud from the ore ceased to be plentiful. This also has ceased to be worked for some time.

In 1815 one specimen of fused copper from the Gangoli mine and several specimens of the ore in matrix were sent to the mint at Calcutta for assay. The report showed that the ore was mixed with arsenic and sulphur, and produced 25 per cent. of malleable metal, but the specimens were too small to allow of any exhaustive examination of them.¹ In 1826 Captain Herbert

¹ To Government, dated 14th June, 1815.

From ditto, dated 13th January, 1816.

valued the outturn at 35 per cent. of the pure ore, and in 1836 Captain Drummond gave the general result from the pyrites in their perfectly pure state as about 30 per cent. of metallic copper.¹ Pyrites, though not a rich ore, is the most important of any, from its abundance and from being generally more to be depended on for continuance than the richer varieties. In England more copper is obtained from it than from all the other ores together. The Gangoli, Síra, and Sor mines were farmed from the conquest until 1828, when they were leased for one year to the miners,² and were again farmed at a reduced rent in 1833. In 1815 they yielded a revenue of Rs. 850, increased to Rs. 1,201 in 1819 and 1820, and to Rs. 1,215 in 1821 and 1822, but in 1874 the whole of the copper mines of Kumaun brought in a revenue of only Rs. 30 a year.

The Síra mines in Patti Bárabási in pargana Síra are situated on the northern side of a hill somewhat higher than the one at Rái. The ore here too consists of copper pyrites, accompanied by iron pyrites in a gangue formed of dolomitic and talcose rocks. Captain Drummond found that nearly thirty-three fathoms from the entrance the adit struck on a copper lode on which a level passage was driven that continued westward, its course being about 10° west of south, and the dip northerly from 45° to 50°. The ore was harder and more mixed with iron pyrites than the ore at Rái. At the end of the level a second lode yielding a poor ore was met, and beyond it a pit was sunk which seemed to have yielded in former times fair returns.

The Gaul mine in Patti Kharáhi and the Sor Gurang are similarly situated, but the ore produced is in very small quantities, consisting of grey copper, copper pyrites, and carbonate of copper. Steatite and limestone are the neighbouring rocks, the steatite forming the gangue. The Sor mine had not been worked up to 1833, although a lease at a small rental had been taken out in 1821.³ Captain Herbert notices that all these ores are free from the presence of arsenic, which, above all other metals, deteriorates the quality of the copper and is most difficult to remove.

¹ See further Stat. Kum., p. 359 : J. A. S. Ben., VII., 935.

² To Board, dated 2nd January, 1829.

³ To ditto, dated 14th February, 1829.

In digging the foundations of a house at Hawalbágh the workmen came on a vessel containing three crystallized specimens of Bournonite, the triple sulphuret of copper, antimony,

Bournonite.

and lead, and the only trace hitherto discovered of its existence in these hills (1826). Copper pyrites also exist near Ganai and Phadiáli in Patti Athgáon in pargana Gangoli; at Bujúl and Ratháyat in Patti Bel in a matrix of steatitic and felspar; and at Tamba Patti in Patti Gangoli in a matrix of talcose rocks. There are small mines in Patti Gíwár at Chin ka Kali, Beler, Sor, and at Kema-khet on the east bank of the Ladhiya river in Kali Kumaun.

The mines of British Garhwál are more extensive and have always borne a higher reputation than those of Kumaun. The principal are situated at Dhanpur and Dhobri in pargana Dewalgarh. These mines yielded a considerable outturn in former times, but of late years operations have not been so vigorously carried on, owing to the intricacy of the workings, and the idea prevailing among the miners that very little ore remains in the mines.

The Dhanpur mine is situated on the north side of a high and precipitous range in compact dolomite.¹ The ores are principally copper pyrites and grey or vitreous copper ores, with the red oxide and green carbonate in smaller quantities, the latter being scarce. The ores are found in a bed about fifty to sixty feet wide, which runs nearly north and south, and underlies east about one foot in the fathom. It is divided by a bed of potstone or indurated talc, which runs through the copper formation longitudinally, conforming to the strata and having a frith or flukan on the western side. The seams of ore are sometimes one foot in thickness, but seldom more than one inch. In 1838 the best seam seen by Mr. Wilkin was not more than half an inch, and in 1841 the best was about two inches. The veins are very close together, and being softer than the matrix, the ore used to be first removed, and then the miners burned the rock with wood and threw water on it to facilitate removal. The red dolomite is of such a consistence as to seldom require props for its support, thus enabling the miners to dispense with wooden

¹ Mr. Wilkin's report, J. A. S. Ben., XII., 454; Reckendorff's report, *ibid*, XIV., 471; Captain Herbert to Commissioner, 10th January, 1826.

framework and to work all the year round, while the situation of the mine on the top of a hill admits of adits for drainage. The interior consists of a network of chambers from end to end.

The Dhubri mine is situated on the south side of the Dhanpur range in very nearly the same kind of rock as the Dhanpur mine, but in this mine most of the veins are horizontal, running along the side of the hill. At the surface they are very small, containing oxide of iron and green stains of copper, and occasionally copper pyrites. The present working mine is not extended very far from the outside of the precipice or surface, the ores being much the same near the surface as at a distance from it. When the miners find their passages growing long and tedious they begin outside on a new vein. There are several old mines west of the Dhubri village; one of them is very extensive, and the ores seem to have been most abundant when the horizontal vein was crossed by perpendicular ores; but the whole of the horizontal vein has been taken away. The most western of these veins is said to have been very rich, but it fell in about the time the Gurkhas entered the province, and has not been opened since. The ores of these mines are principally copper pyrites, worth 25 per cent. of copper.

There is water for machinery about a mile and a half below the mine, and wood for all purposes near that place. There is another mine on this range at Maulgiri, said to be in the same rock as the Dhubri mine. There are other mines of both copper and iron in Dhanpur, but few of them are worked, and they are for the most part of little value. There is a copper mine in Patti Lohba¹ at Agar Sera¹ in the face of a precipice on the right bank of the Rám-ganga river which was leased in 1872 for three rupees. The lessee, however, makes little profit, as the shafts have been sunk so deep that men are afraid to enter them, and the rock is too hard to allow of fresh shafts being driven, unless at great expense.

The Pokhri copper mines early attracted the attention of the Government of the country. For many years they had been worked by the Garhwál Rajas, and subsequently by the Gurkhas. They

¹ Described by Beckett in *Sel. Rec.*, N.-W. P., III., N. S., 371.

consist of several separate mines; that known as the Chaumattiya mine. Chaumattiya is situated in talc which rests on dolomitic limestone. The lode after crossing the ridge east of the mine enters a very compact basin, in which is situated the Duined mine. This has not been worked much, owing to the softness of the talc and the abundance of water, but it is said to have a good lode in one part of it. The lode then crosses the hill near Deothan, a small village above the mine, and is found near Gúgli and Keswara, where some ores have been extracted, but never proved very profitable in working.¹

The Raja's mine is situated about 450 yards north of the Chaumattiya mine in common dolomite which rests on talcose schist. A shaft of 70 fathoms was dug by the early workers meeting an adit which must have been driven over 100 fathoms through dead ground. Several other adits were driven, and when they fell together, about one hundred years ago, there were three places where copper was found—the Gaja Chauk, Kuvera Chauk, and Bhartwál Kúa, all of which have now fallen in. The produce was about 300 sers of ore a day, yielding 25 per cent. of copper. Two-thirds were claimed by the Raja, and the remainder was left to the miners, who had also grants of land free of revenue. The experiments of Mr. Wilkin already noticed were confined to these two mines and a new mine which he opened close by. In the new mine the lode was very promising and yielded good specimens of ores near the surface, but at a depth of fifteen fathoms it became poor, and was consequently abandoned. During the time the experiment lasted the expenditure on the Chaumattiya mine amounted to Rs. 2,847, and the return in copper to Rs. 231, besides about three to four hundred rupees' worth of ore. Rs. 347 were expended on the Raja's mine, and the experiment was then abandoned, and the new mine cost Rs. 240 before the operations were closed. The entire net cost of the undertaking when operations ceased was for labour in working the mines, less sale proceeds of copper, Rs. 2,585, and for European superintendence Rs. 4,800, or a total of Rs. 7,385. These mines were then leased to a native contractor for Rs. 500 a year.

¹ For details of these mines see Mr. Wilkin's report in J. A. S. Ben, XII, 454, and Reckendorf in *ibid*, XIV., 471.

In addition to the three mines mentioned above there are several others in the vicinity of Pokhri, some of which were worked by the former rulers, and some again have never been opened. Mr. Wilkin noticed the principal mines, and described them as follows :—

The Nota mine is situated about two and a half miles north-west of the Pokhri mines in talc, which
Nota mine. rests on dolomite limestone. The lode is a bed of yellow or buff-coloured talc, about four feet wide, dipping north-west at 50°; it rests immediately on the dolomite limestone, and has a sulphuric effervescence on the surface. This mine is said to have been rich; it is situated on the western side of an extensive basin or valley, on the eastern side of which ores have been turned up by the plough, but no mine has been worked. This is an extensive field for mining, as the lode may be productive throughout the basin or valley. There is wood and water for all purposes near this mine.

The Thala mine is situated about a mile north-west of the
Thala mine. Nota mine, probably on the same lode, in an extensive plain or comparatively level surface. It was first worked in 1810, and again in 1825, but there being no good facility for adits, the water prevented its being worked to any considerable depth. The miners who worked it state the ores to be copper pyrites disseminated in a lode of two feet wide, one-fifth of which was metalliferous. There is plenty of wood for all purposes in the neighbourhood of this mine.

The Danda mine is situated on the hill, about 500 yards
Danda mine. above Thala mine, in chlorite slate and talc, which on the north-western side comes in contact with common dolomite. This mine has been worked to a considerable extent, and is said to have yielded Rs. 52,000 profit in one year. The ores are of good quality, and found in three or four different beds or holes which dip into the hill at an angle of 30°. The chlorite slate in which the beds of talc and ores are found is so hard as to stand without timber; it also contains finely disseminated copper in small quantity. The lodes run into a fine fall or basin westward, in which Mr. Wilkin

thought they would be found productive. There is abundance of wood near this mine, but no water for machinery nearer than the Thala mine.

The Talapúngla mine is situated about a mile north-east of the Danda mine in talc, which rests on Talapúngla mine. dolomitic limestone. The strata in which the ores are found is about six fathoms wide, dipping south-west at various angles. The bed is extensive, but the ores are scarce; however, this might improve at a distance from the surface. Ores have been found in a precipice, east of this mine, near the village of Bangtal, but at present the outcrop is covered with rubbish; it is in the talcose formation, and has good facilities for working.

The Kharna mine is situated in the ravine below Bangtal, near its junction with the Nagal river in talc; it was discovered by the water of the ravine washing away the strata, and leaving a quantity of ores exposed to view; these ores were taken away by the Pokhri miners and the mine worked five or six fathoms under the surface, beyond which they were prevented from going by the water. They say that the lode at the bottom of the mine for two fathoms in length is one foot wide, of solid copper pyrites. Of late years nothing has been done at this mine beyond washing among the surface, which contains a small quantity of copper pyrites. There is plenty of wood in the neighbourhood of this mine and water for machinery, but no facility for adits.

The process of manufacture of copper has been fully noticed by Mr. Beckett in *Sel. Rec., N.-W. P., III., N. S., p. 22*, and need not be further mentioned of here.¹ The copper mines of Dhanpur in Garhwál were leased in 1872 to a European who employed about 100 men; but even then Western intelligence and energy were unable to make this mine pay. There is a copper mine in Patti Lohba at Agar Sera in the face of a precipice on the right bank of the Rámghanga river which was let in 1872 for three rupees. The lessee makes little profit, as the shafts have been sunk so deep that men are afraid to enter them,

¹ See further Glean. in Science, I., 230; *A. S. Res., XVIII. (1), 227* (Herbert); Traill and Batten, *Statistics of Kumaun, Agra, 1851*.

and the rock is too hard to allow of fresh shafts being driven, unless at great expense. The great drawback is the scarcity of labour, as most of the miner caste have now turned to agriculture, which they find pays much better and gives a more secure return to their labour. Copper is sold for about a rupee per pound in Garhwál.

The iron ores found in Kumaun all belong to either of two varieties, the rhombohedral or the prismatic.

Iron mines.

The first is a peroxide of iron containing in its best defined type 70 per cent. of iron and 30 per cent. of oxygen. The workable ore, however, often contains earthy impurities which reduce the proportion so low as 50 per cent. of metal. This is the common species. A variety of this, known as red hæmatite, also occurs in many places, and frequently contains small grains of specular iron ore of a highly splendid lustre. At Rámgarh it passes into the variety known as scaly iron ore, consisting of loosely cohering glimmering particles of a steel-grey or iron-black colour, strongly soiling and feeling unctuous to the touch. Captain Herbert considers these beds connected with those at Dhaniya Kot on the Kosi. Both yield very good iron. The prismatic species or hydrated peroxide is only known to occur in the Chaugarkha pargana.

The following are the principal iron mines in Kumaun. In Patti Agar of the Rámgarh pargana, as

Kumaun mines.

noted, the iron is of the species known as scaly, somewhat laminated in structure, slightly micaceous, and influencing the magnetic needle. The names of the principal mines are the Lúsgáni, Nathúa Kán, and Gulla; the Satbúnga mine has a rich hæmatite. In Patti Rámgarh also there are several mines that are largely worked. In the Chaugarkha pargana the ore of the Muniya mine in Patti Lakhanpur is of the prismatic species. It is of two varieties, the ochry and compact. The former sometimes contains octahedral crystals and magnetic iron ore, and in the neighbourhood of the mine on the summit of a small hill there occur rolled pieces consisting of grains of quartz and small octahedral crystals of this mineral cemented together. These pieces are magnets, and have each two poles. The ores too contain manganese in notable proportion, and would consequently afford a very good steel, as it is

to the alloy of this metal that the superiority of the steel manufactured from brown ore is attributed. In Patti Dárun there are mines at Digarhia and Jhiratoli of the same nature; in Rangor Patti at Jalal and Digarhia; in Patti Kharahi at Lob. A specimen of iron ore brought from the neighbourhood of Milam, called by the natives of Malla Juhár '*buddunga*,' seems a crystalline variety of red hæmatite. It is used there for a red dye, the colour being extracted by rubbing the stone on a hard surface while wet.

The mines of Patti Giwar in pargana Páli are found at Chiteli, Sirauli, Khetsári, Simalkhet, Gudí, Bailgaon, Giwar mines. Bonigarh, and close by at Mehachauri and Tilwára. The valley in which the iron is produced runs nearly north and south, and extends from Dwárahát on the south to Pandúa Khal on the north. It is formed by the rivers Kotlar and Khetsári, both flowing into the Rámanga, the bed of the former being about nine miles long, and that of the latter six miles. The ores lie on the east side of the valley. The Simalkhet mine is the largest, and has four entrances penetrating upwards of 350 feet into the mountain. The ores here consist of red hæmatite in a gangue of clay slate branching in every direction and at all angles. The lodes range from 3' to 18' in width and 2½' to 15' in height, the average being from 3' to 5' by 4' to 6'. There is no water, and the surrounding rock is compact, requiring few supports.¹

In Sayalgarh of pargana Kotauli there is some iron ore not at present worked. At Manglalekh in Talla Rao the ore is much esteemed for its quality, and is raised in some quantity. At Dechauri, Rámgarh, and Khurpa Tál the mines are in the hands of the Kumaun Iron Works Company. The Lugthan mine is in Malla Katyúr, and there is another in Baráon Patti in pargana Gangoli. The burrows at Khairna are now unworked, likewise those at Simalkha and Uchakot.

In the Garhwál district the iron mines in Patti Painkhanda exhibit specimens of granular iron pyrites Garhwál iron mines. imbedded in veins of quartz which occur in a dark-greyish talcose schist. They are apparently not very

¹ Beckett, III., Sel. Rec., N.-W. P., 23.

rich in ore. In Patti Sílí Chandpur the Rajbúnga mine gives a rich hæmatite which is slightly attracted by the needle, and is still worked. The Khúsh mine in the same patti gives a micaceous ore, scaling off easily and showing minute crystals resembling garnets on the edges of some specimens. The adjacent beds seem to be chloritic schists; this ore affects the needle. In Taili Chandpur a magnetic ore is found with hæmatite, and a specimen from Patti Talli Káilphát resembles specular iron ore.

Specimens from the Búkhanda mine in Patti Bichhla Nágpur are also of a micaceous nature, and seem to contain in parts minute crystals of quartz and pyrites, otherwise they much resemble graphite, and soil the fingers when touched. They do not influence the compass needle. The Jákhtoli mine in the same patti gives an ore which is probably a clay ironstone. It is of a light coffee colour and of little specific gravity. The Gílet mine close by gives an ore of a similar quality. In Malla Nágpur the ore is probably hæmatite. A vein of iron pyrites runs along the Alaknanda in this patti near the village of Hath. The people call them '*sona ke pathar*,' or gold stone, and sell them to the pilgrims to Badrináth at high rates. The stones in the form of powder are used as an orpiment, and the stone itself as a flint. A specimen from Nágpur itself is probably a carbonate of iron.

The Mok mine in Patti Malli Dasauli yields an ore of which specimens appear to be magnetic, rich in metal, black in colour and crystalline, and laminated in structure. It possesses highly magnetic properties. The Charbang mine in the same locality is of a similar character, very rich in iron, and, according to Mr. Lawder, exhibits its polarity in the direction of the planes of lamination. The Dúngara mine in Patti Bachhansyún gives specimens which may possibly be an earthy hydrated oxide of iron. Its colour varies from ochry to dusky black, streak the same. It is of little specific gravity, the clay seemingly predominating.

The ore of Pípali mine in Patti Iriya Kot is probably a hydrous form of sesqui-oxide of iron, the clay largely predominating. The Danda Toli mine in the same patti seems to give an argillaceous

variety of brown hæmatite. Lohba affords a rich hæmatite, raised in large quantities. The Chalya mine in Patti Painún gives a hard and brittle ore possessing the iron-black colour and metallic lustre of magnetic iron, but specimens of it fail to affect the compass needle in the manner characteristic of that ore. It may possibly on analysis be found to contain manganese. The iron of the mines in Patti Bachhansyún is considered the best in Garhwál, and sledge-hammers manufactured from it have been found to last out the best English iron. This iron is peculiarly hard, and yet not brittle. Mr. Beckett in 1850 gave a detailed account of the principal iron mines in the Kumaun division, their mode of working, outturn, and prospects, which will be found in Sel. Rec., N.-W. P., III., N. S., 22, and need not therefore be further noticed here.

The deposits of lead are numerous.¹ The ore is found at Táchhíra in pargana Dhanpur mixed with a little silver. A large mine also existed at Ghirti in the snowy range between Milam and Nítí, but this has lately been closed by a landslip. The mines at Ralum and Banskum on the banks of the Gori river and at Baidli Baghir are unworked. The ore is galena, and the matrix is siliceous, with varying proportions of felspar and calcspar. The Nagpur mine is a fair one, but somewhat inaccessible. Near the Gaul mine in Patti Kharáhi and at Sor Gurang copper mines there are deposits of lead ore. The former is a galena traversing a siliceous limestone. Neither are regularly worked. When the villagers require lead they burn the rock, and the lead more or less sulphuretted trickles from the crevices. A large nodule of lead, the size of an eighteen-pound shot, was found in Patti Maundarsyún on the banks of the Nyár river. It consisted of pure galena, but though search was made no more could be discovered.

Yellow arsenic, known as *haritál*, is found in the northern parts of Kumaun near Múnsyári. A small portion is brought down every year by the Bhotiyas for sale at the Bageswar fair in January.

¹ Lead sells at three pounds for a rupee in Garhwál. See Glean. in Science, I., 230.

Indications of lignite appear near Ránibágh close to Halduwáni, the Barakheri pass near Bhamauri, and in the streams of the sub-Himálaya near Najibabad in the Bijnor district. They do not give promise of any workable fuel, and, judging from the experience obtained in other parts of the hills, it is questionable whether any lignite deposits will ever be discovered of such extent and quality as to repay the expense of mining them. An analysis of a specimen of the Ránibágh lignite gave carbon 60·0, volatile matter 36·4, ash 3·6. The percentage of ash, however, contrasts favourably with Bengal coal.¹ Traces of a true peat are found at Bhím Tál.

Graphite² (plumbago) crops out at the Kalimatiya hill to the north of Almora and on the spur of Banini Devi facing Almora on the Lohughát road. In 1850 specimens were sent to England and subjected to examination, when it was found that it could not be made serviceable as graphite. The excavations were made by Major Drummond at Garjoli near Balti, and Palsími, about three miles from Balti and the same eastward of Almora. The following is the report of Mr. Rose, the mineralogist who tested the specimens sent from Almora:—
 “Graphite is applied to several purposes. When very fine, compact, and of a sufficient cohesion, it is cut up for drawing-pencils. When the texture is loose, or it is otherwise of inferior quality, it is ground down and deprived of foreign substances by washing, as ores of metals are prepared for smelting. The powder thus purified is then used for various purposes, such as crucibles (being refractory or infusible by heat) for burning iron, and reducing the friction of machinery. A new method is now adopted for making artificial pencils, which are scarcely, if at all, inferior to those sawn out of the finest blocks. The dust of such fine material as your specimens Nos. 4, 8, and particularly No. 10, properly prepared, is subjected to vast hydraulic pressure (several hundred tons), and thus acquires the compactness and solidity necessary for the best purposes. The best kinds of graphite may be known by a pale lead-blue colour, high lustre, unctuousity, and

¹As. Res., XVI., 387, 397.

² See further Glean. in Science, III., 280; J. A. S., XXIV., 203; In. R., ec. (H. D.), XVII., 58; Rec., N.-W P., III., N. S., 371.

inferior specific gravity. The first nine specimens will answer for pencils, most of them sufficiently pure and compact to be divided for that purpose. All the varieties sent may be used, even No. 13, though connected with much matrix, as it can be deprived of this by grinding and washing. All the varieties of this substance must continue in demand and bring remunerative prices if the expense of mining and conveyance should not be too great." It is also found in Patti Loliba of Garhwál on the Karnprayág road, and is there used as a dye.

Sulphur is found both in Kumaun and Garhwál. In the former district at Múnsyári, in the northern part of the district, and there are also some sulphureous springs, as those at Nainí Tál, Nargoli, and Káthgodám. There are two sulphur springs in Garhwál: the first lies close to the snowy range to the north-east of the temple of Madh Maheswar in pargana Nágpur; the other is on the left bank of the Biri river, two miles above its junction with the Alaknanda. The water of this last is so very strongly impregnated that its existence can be discovered by the smell long before arriving at the spring itself. Neither are made use of any way.

Borax or tincal, a native saline compound of boracic acid and soda. The borax and salt fields of Gnari or Húndes, *lha-lhaka* or *lhali-lhaka*, lie to the north of Bongbwa Tál, across mountains that round the north-east side of the valley of the Shajan river, parallel to the Gangri range, and in the eastern part of the Zjang of Rohtoh (Rudukh) and at the Chapakani lake. The two salts are obtained from different spots in the same vicinity, and are both worked in the same way by lixiviation from the earth taken from the surface of the ground in which the salts are developed by natural efflorescence. These salt fields are open to all who choose to adventure their labour in them on payment of one-tenth of the produce to the Lhasa Government, who have an excise establishment on the spot.¹ The borax is collected from June to September and sold at the different fairs—Ganpa, Gartoh, Sibilam, Chájna Taklakhar, Dabakhar. It is brought

¹ H. Strachey : J. A. S. Ben., XVII. (2), 57.

down by the Bhotiya traders and purchased by the merchants of Rámnagar, where it is refined. The process is as follows :—The borax is pounded and placed in shallow tubes, and then covered with water to the extent of a few inches; to this is added a solution of about two pounds of lime dissolved in two parts of water, for every ten maunds (820 pounds) of borax, and the whole mass is well stirred every six hours. Next day it is drained on sieves or cloth, and after this is again dissolved in $2\frac{1}{2}$ times its weight of boiling water, and about sixteen pounds of lime added for the above quantity. It is then filtered, evaporation takes place, and subsequently it is crystallized in funnel-shaped vessels, usually of *kansa*, an alloy of copper and zinc, or lead. The loss in weight is about 20 per cent. Borax is used in medicine and the arts. Dry borax acts on the metallic oxides at a high temperature, meeting and vitrifying them into beautiful coloured glasses. It is also used as a flux for soldering in goldsmith's work and as a varnish combined with shell-lac. Its principal use is, however, in the manufacture of coloured glass, enamel, and glazed substances. ¹

Gypsum is found in pargana Chhakháta. Perhaps the best bed is near the Nihál bridge on the road between Káládhungi and Naini Tál. In 1850 Mr. Tregear, of the Bareilly College, made some very good plaster of paris from it, which might be found useful in external plastering, as it has the property of expanding on cooling. Gypsum is found in Garhwál on the banks of the Alaknanda near Panai and Nagrasú. There is also a dark-green variety which the people sometimes make into saucers and bowls. ²

A white saponaceous stone resembling and used for the same purpose as pipe-clay is produced in many Soap-stone. places. In Garhwál various vessels are turned from it, which when polished have the appearance of marble. They retain liquid, but being extremely brittle are little used.

Asbestos has lately been discovered in the hill to the north, and at a short distance from Ukhimath in Asbestos. Garhwál. It is said to be of very good

¹ Ure, I., 381, ² As. Res., XVIII. (1), p. 216.

quality, but it is too far inland to be profitably worked. The people use it medicinally for dressing wounds and burns, and as a wick for oil-lamps, but it may yet be turned to a profitable account as a packing for steam-joints and the like.

Silajit¹ or salajit, a native sulphate of alumina, is found both in Kumaun, Nepal, and parganas Painkhanda and Nágpur of Garhwál. It is much sought after and used as a dressing for wounds.

Limestone is found all over the division, both in immense masses exhibiting various shades of colour and structure, and as local tufa deposits. There are three distinct ranges of limestone hills in Garhwál: the first north of the Alaknanda in Nágpur, the second running from Lohba Patti to the Pindar, and again to the Alaknanda in Patti Bachhansyún, and the third running parallel to the plains and south of the Nyár river. There are also small patches of limestone scattered throughout the district, but not in such large quantities as in the abovementioned ranges. Lime is manufactured at Naini Tál, at Jyúli in the Kharáhi range, half-way between Bageswar and Almora, at Chiteli, north of Dwárahát, at Simalkha, Baitalghat, and Dhikuli for Ránikhet, and on the new cart road to Rámnagar. Lime is also made in Borarau, Sor, Síra, Dhyánirao, and Charál. Two kinds of limestone are used in the Tarú district, the one being obtained from the quarries at the foot of the Kumaun hills, which give by far the best kind of lime; the other is the tufa deposit obtained in the small nálas of the tract itself; this latter kind, however, is of a very inferior quality. First-class limestone costs at the quarries five to eight rupees per 100 maunds; the tax levied by the Forest Department is eight rupees on that amount, and cartage may be averaged at half a rupee per mile for 100 maunds. Thus the stone is landed at most points in the district for 30 rupees per 100 maunds, and including the expense of burning, a maund of lime costs 10 to 12 annas. This lime will bear two or three portions of pounded brick or *sunzi*. Second-class lime ready for use costs 25 rupees per 100 maunds; it will, however, only bear a proportion of one part of pounded brick to two parts of lime.

¹ J. A. S. Ben., II., 321, 482; Rec. Geol. Sur., II., 86; III., 43. The name is derived from *silā*, 'a stone,' and *jít*, 'principle or essence.'

Almost everywhere in the hill districts good building stone can easily be procured. At Almora fine Building stone. grained, evenly bedded quartzites and mica-schist form the hill itself, and supply material not to be excelled for durability and facility of dressing. Mica-schist seems to form the principal beds for some distance to the east and west of Almora, reaching to Dwárahát and Mási on the west, Páli, Ránikhet, Síyáhi Devi, Dol, and towards Káli Kumaun to the east, and also in the formation of the Jageswar and Binsar ranges to the north. At Naini Tál the stones used are limestone and clay schist. At Ránikhet a pale-coloured gneiss forms both a handsome and a lasting building stone. Sandstone is abundantly found in the lower hills. Gneiss and chlorite schists are used frequently as building stones in the district. In the Bhábars plit boulders are found to answer the purpose of bricks.

At Chiteli near Dwárahát there are roofingslate quarries, now unworked; also at Dhári in the Bel Patti of Gangoli; in Borarao Patti, Sult Patti, and at Naini Tál. In Lohba of Garhwál the thin dark-blue slate is procurable. But these last appear to be much inferior to the Chiteli quarry.

Alum, known as *phitkari*, is found in different parts of the province, and in abundance in the aluminous shales near Ják village, on the road from Naini Tál to Khairna. This shale contains minute particles of pyrites disseminated throughout its mass, which on becoming decomposed promote the formation of alum. The lixiviation produced by water leaves an encrustation of alum on the rock. A dark-coloured talc called *jalposhi* is exported to the plains and used as a medicine.

There is no doubt but that in both quantity and quality the metalliferous deposits in this division are good, but the absence of coal and the competition of sea-borne metal have hitherto rendered mining an unproductive speculation, nor does there seem any probability of it attaining any important position among the industries of the province.

ALLAHABAD, }
1st December, 1877. }

[E. T. ATKINSON.]



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